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CAD/CAM Activities at NRC: 1988

J.H.C. Scrimgeour and B. Van den Berg (Editors)

June 1988

Canada

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PREFACE

The NRC report "CAD/CAM Activities at NRC," NRCC 25719, prepared by F. Vernadat and members of the NRC CAD/CAM Interest Group, has proven to be a useful document to inform individuals, both inside and outside NRC, of the current projects in a number of Divisions.

Accordingly, we are pleased to provide this up-dated edition. As before, the projects described originate from many NRC Divisions, including the Division of Mechanical Engineering, Division of Electrical Engineering, Industrial Materials Research Institute, National Aeronautical Establishment, Institute for Research in Construction, the Herzberg Institute of Astrophysics, Informatics Division, Institute for Marine Dynamics, and Division of Biological Sciences.

The purpose of this report is to provide brief informative descriptions of current projects and work in progress. In instances where further information is required the individual project personnel may be contacted, as indicated.

For project descriptions and published papers relating to past and completed work, the NRC publications "Advances in CAD/CAM and Robotics" may be consulted, either in the condensed form (NRCC 28126) or in the complete edition which contains many of the representative papers (NRCC 27454). For information on the availablilty of these two publications, please contact: Editorial Office, Division of Electrical Engineering, National Research Council of Canada, Ottawa, Ontario K1A 0R8.

J. Scrimgeour - Division of Electrical Engineering

B. Van den Berg - Division of Mechanical Engineering

Co-editors

PRÉFACE

Le rapport s'intitulant "CAD/CAM Activities at NRC", CNRC 25719, préparé par F. Vernadat et des membres du Groupe d'intérêt sur la CAO/FAO du CNRC, s'est avéré un document très utile pour informer les gens, tant à l'intérieur qu'à l'extérieur du CNRC, des projet en cours dans un bon nombre de divisions.

Ainsi donc, nous sommes heureux de pouvoir offrir cette nouvelle édition à jour. Tout comme avant, les projets décrits émanent de nombreuses divisions du CNRC, dont la Division de génie mécanique, la Division de génie électrique, l'Institut de génie des matériaux, l'Établissement aéronautique national, l'Institut de recherches en construction, l'Institut Herzberg d'astrophysique, la Division de l'informatique, l'Institut de dynamique marine et la Division des sciences biologiques.

On rapport a pour but de fournir des descriptions brèves et informatives des projets et des travaux en cours. Lorsque de plus amples informations sont requises concernant un projet particulier, il est possible de communiquer avec la personne dont le nom est indiqué.

Pour obtenir des descriptions de projets et des articles publiés portant sur des travaux complétés dans le passé, la publication du CNRC "Advances in CAD/CAM and Robotics" peut être consultée, soit sous sa forme abrégée (CNRC 28126), soit sous sa forme intégrale qui renferme un grand nombre d'articles représentatifs (CNRC 27454. Pour se renseigner au sujet de la disponibilité de ces deux ouvrages, il suffit de s'adresser au : Bureau des publications, Division de génie électrique, Conseil national de recherches du Canada, Ottawa (Ontario) K1A 0R8.

J. Scrimgeour - Division de génie électrique

B. Van den Berg - Division de génie mécanique

Corédacteurs

Division: Institute for Research in Construction

Section: Building Performance

Project Title: B16.1 Building Object Representation

Project Leader: K. Ruberg Phone No 993-9711

Project Description:

Objectives

To develop a universally applicable data and procedure structure representing the building envelope. This will provide the basis for developing a design aid and a diagnostic prototype for any part of the building envelope.

Function in Program

Fundamental research into:

- the objects and network comprising the building envelope
- the software structure necessary to support the object network definition

Resources:

Persons: 3

Hardware: 2 Symbolics 3620

Software: 2 IBM PC AT's

External Cooperation (if any):

Papers published (if any):

"Advanced technology for Building Construction", CIB86, Washington.

"A knowledge-based system for diagnosing window problems", ICBEM 87, Lausanne.

"Advanced technology roundtable proceedings" IRC No. 534.

Division: Institute for Research in Construction

Section: Building Performance

Project Title: B16.2 Knowledge Acquisition Techniques - Case-Based Rule Generation

Project Leader: K. Ruberg Phone No 993-9711

Project Description:

Objectives

To develop a program that builds rules from consensus reached with many experts.

Function in Program

Fundamental research into:

- knowledge acquisition and KBS interfaces with expert (computer naive) users

Application of expert systems:

- prototype consensus system

Resources: See 16.1

Persons:

Hardware:

Software:

External Cooperation (if any): Coplanam (Montreal)

Papers published (if any):

Division: Institute for Research in Construction

Section: Building Performance

Project Title: B16.3 Knowledge Acquisition Techniques - Consensus Role Generation

Project Leader: K. Ruberg Phone No 993-9711

Project Description:

Objectives

To develop a program that builds rules with the help of an expert diagnostician from case descriptions of building envelope failure.

Function in Program

Fundamental research into:

- knowledge acquisition and KBS interfaces with expert (computer naive) users
- classification algorithms and rule structures

Application of expert systems:

- prototype rule builder and classifier

Technology transfer:

- develop system with Coplanam observed failure database and transfer system to Coplanam,
- develop system in collaboration with Coplanam.

Resources:

Persons: See B16.1

Hardware:

Software:

External Cooperation (if any):

Papers published (if any):

Division: Institute for Research in Construction

Section: Building Performance

Project Title: B16.10 Building Representation using Database Techniques

Project Leader D.J. Vanier Phone No 993-9699

Project Description:

Objectives

To develop a universally applicable data structure for the IGES file transfer utility. The work supports industry's need for Canadian representation on the IGES Initial Graphics Exchange Standard) Architecture and Building Subcommittee. The objective is to define a numeric and lexical data structure to accompany the graphic data structure presently used in IGES.

Function in Program

Applied research of:

- specification data structure and links to graphic components
- existing IGES table data structures and IGES workplan for data representation

Resources:

Persons: 1

Hardware: Mac II

Software:

External Cooperation (if any):

Papers published (if any):

" Integrated computer-aided design", ARECDAO, April 1987.

"A standard for CAD (construction)", CIB 86, Sept. 1986.

"A benchmark procedure to evaluate CADD systems, IRC publication #58.

Division: Biological Sciences

Section: Electronics Design

Project title: Computed-Aided Design for Printed Circuit Board Design

Project leader: G.M. Charette **Phone no:** 613-990-0868

Project description:

The Electronics Design Group uses micro computers with Wintek CAD Software to make printed circuit layouts and schematics of electronic circuits. Prototype and small quantities of printed circuits are produced for the Division of Biological Sciences, Chemistry Sussex Drive and Physics Sussex Drive.

IBM AT's and AT clones with EGA Colour Monitors are used with Smartwork for printed circuit board design and Hiwire for making schematics. An HP 7470A Plotter and a Houston DMP 41 plotter are used to produce the artwork. The artwork is output on velum and a printed circuit board mask is produced photographically without reduction.

Resources:

Persons: 5

Hardware: IBM AT, ZEGNA at HP 7470A Plotter, Houston DMP 41 Plotter

Software: Smartwork, Hiwire by Wintek

External cooperation (if any):

Papers published (if any):

Division: Mechanical Engineering

Section: Manufacturing Technology Centre

Project Title: CAD/CAE in the MTC Design Office

Project Leader: Glenn Merrett

Project Description: Phone No: 613-993-7460

The design office of the MTC is in the process of changing its CAD operations for machine design from a terminal based system with a central CPU to a more distributed system. Central to this change has been the importance of incorporating CAD into the natural design process. As a result we have begun purchasing a microvax 2000 workstation for each designer, to be located at their work area rather than a separate CAD room. These workstations will be clustered together to allow the benefits of a central data base and system management, while giving the independent standalone performance which tends to be highly desired by designers.

We also provide design service and expertise for two microcomputer based CAD packages (Autocad and Computervision). This accommodates the needs of other NRC laboratories for low cost CAD systems in either 2D or 3D. We also support the CAM package for the Computervision software.

The design office has added finite element capabilities to compliment its CAD packages. The NISA package is available in the design office based on a personal computer and we have access to a version running on an IBM mainframe for larger problems. This software can be interfaced to both Unigraphics and Autocad.

Resources:

Persons: 6

Hardware: Microvax 2000, Unigraphics workstations, Tektronix 4129 workstation

Software: Unigraphics, Computervision, Autocad, NISA

External cooperation (if any):

Papers published (if any):

Division: Herzberg Institute of Astrophysics April 1988

Title: CAD/CAM & THE HERZBERG INSTITUTE OF ASTROPHYSICS

Project Leader: Joseph R. Fletcher Telephone: (613) 991-5850

Starting in 1985 the Herzberg Institute embarked a program to use of more computer aided design and manufacturing equipment to increase productivity. This action was prompted in part by an increasing need for a better design and drafting capability and was partly in response to a reduction of staff levels. The result has been very satisfactory with a relatively large number of CAD stations installed and well used by a large number of adequately trained people. Draftsman, designers, machinists, technologists and scientists are all now regular CAD users. The observatories in Victoria and Penticton, B.C. as well as the CFHT and JCMT telescopes in Hawaii have compatible CAD instillations. The CAD/CAM hardware presently employed within the HIA is as follows:

CAD EQUIPMENT - OTTAWA LABS

1. ORCAtech 1000 workstations - TRAX Software
   Quantity 3

2. IBM PC/AT or Compatible all equipped with color display, printer, extra memory, coprocessor and pointing device.
   Quantity 11

3. Summagraphics digitizer tablets
   Qty 2 - 12" X 18" in Design Office
   Qty 2 - 12" X 12" in Radio Astronomy Labs

4. Pen Plotters
   Quantity 2 - HP 7585 "E" Size
   Quantity 3 - HP 7550 "B" Size

CAD EQUIPMENT - DRAO Penticton B.C.

1. ORCAtech 1000 workstation - TRAX Software

2. IBM PC/AT Compatible equipped with HP 7550 plotter.

CAD EQUIPMENT - DAO Victoria, B.C.

1. ORCAtech 1000 workstations - TRAX Software
   Quantity 2

2. IBM PC/AT Compatible - Calcomp plotter.

CAM EQUIPMENT - OTTAWA MACHINE SHOP

1. ENSHU Accu-Mill AM-1547, 3 Axes CNC Milling Machine equipped with FANUC SYSTEM 3M CNC Controller

HIA CAD SOFTWARE

ORCAtech "TRAX" Printed Circuit Board Design

Stand alone units which are used for schematic capture and printed circuit board design. The TRAX software will allow a fully autorouted design of a PC board from the schematic entry part of the program. TRAX will also generate all of the relative documentation such as parts lists, net lists and wire wrap information. CAM output is "Gerber Standard" photoplot files and industry standard NC drill tape files. The TRAX program will also accept Net Lists which have been prepared with the "FutureNET" (IBM PC/AT) schematic capture program listed below to design printed circuit boards using the TRAX PCB layout software.
Contact: Joseph Fletcher at 991-5850

FutureNET "Dash 1" Schematic Capture

Schematic capture, netlist and circuit simulation.
Contact: Robert Hayward at 991-5845

EEsof "Touchstone"

Mirowave computer aided design, analysis and simulation program.
Contact: Doug Wade at 991-5844

AutoCAD - Version 2.52 2.62 and Release 9

General purpose drafting software which is finding use in a very large number of applications. Very good for creating illustrations for scientific papers, overhead transparencies etc. The HIA design office now uses Autocad for virtually all mechanical drawings. The Radio Astronomy and Spectroscopy sections use some of AutoCAD's features for data analysis; in many cases right from the camera ready copy which has been prepared for publication. Indeed many of the illustrations are produced from script files using the electronic (floppy disk) data collected in the lab to produce the AutoCAD drawing data base.
Contact: Joseph Fletcher at 991-5850 or Ed Boyce at 993-1223

FUTURE PLANS

At the moment a large number of people in the HIA are using AutoCAD in a diverse number of applications. This is due to the extreme versatility of the AutoCAD software. Plans are currently under way to better utilize the 3 axes CNC milling machine in shop by purchasing hardware and software which will allow machinists to program and pre-view cutting tool paths for the CNC mill. Consideration is being given to using the AutoCAD drawings produced in the labs and drafting room as the data base. Consideration is also being given to installing a relational database program for shop job management, thereby even further enhancing the operation of the machine shop.

Division: Electrical Engineering

Section: Industrial Liaison Office

Project Title: CAD/CAM Newsletter

Project Leader: J. Scrimgeour Phone no: 993-9000

Project description:

The CAD/CAM Newsletter originally began in August 1979 as a monthly release of information to a number of Canadian trade journals and other publications. In the face of requests for direct receipt, distribution gradually increased to approximately 3000 persons across Canada who had requested receipt on a regular basis. The newsletter, including its abstracts section, provides a world watch service on events, key papers and developments in CAD/CAM and Computer Integrated Manufacturing. Distribution and sponsorship of the newsletter continued through the secretariat of the Canadian Council for the Advancement of Computer Integrated Manufacturing (formerly the CAD/CAM Technology Advancement Council) until August 1987. In 1987 CAN-MATE was established as a national technology and coordination centre operated by the Canadian Manufacturers' Association. CAN-MATE has begun distribution of a regular monthly publication called "Technology Source".

"Technology Source" incorporates part of the CAD/CAM Newsletter, in its printed edition. In addition, the full monthly CAD/CAM Newsletter, for which J. Scrimgeour continues to act as editor, is available via the on-line information database maintained by CAN-MATE. Further details are given in the section of this report describing CAN-MATE.

Resources:

Persons: 1

Hardware:) AES Word processing equipment plus disk conversion
Software:) for compatibility with facilities at CAN-MATE.

External Cooperation (if any): - Input information is obtained from a wide variety of sources, external and internal to NRC.
Distribution is via CAN-MATE.

Papers Published (if any): The CAD/CAM Newsletter is a regular monthly publication.

Division: Electrical Engineering

Section:

Project Title: CAN-MATE

Project Leader: See contact below **Phone no:** see below

Project description:

In 1987 arrangements were completed with the Canadian Manufacturers' Association for the establishment of the Canadian Manufacturing Advanced Technology Exchange (CAN-MATE).

CAN-MATE, a national centre operated by the CMA, will help Canadian manufacturers apply advanced technologies to production and processing in all industries, thereby improving their competitiveness in domestic and foreign markets. These advanced technologies include automated materials handling, testing and inspection, computer-aided design, robotics and artificial intelligence.

Under an agreement between the National Research Council (NRC) and the Canadian Manufacturers' Association, the NRC will provide the CMA with $3.5 million over seven years to assist in the operation of CAN-MATE.

The four principal functions of CAN-MATE will be to:

1. Provide information and advice to industry
2. Organize multi-firm development projects
3. Coordinate the activities of manufacturing technology centres in Canada
4. Provide a national and international perspective to industry, the centres and government.

For further information, contact: CAN-MATE
c/o Canadian Manufacturers' Association
One Yonge Street
Toronto, Ontario M5E 1J9
Tel: (416) 363-7261
(800) 268-8177

Resources:

Persons:

Hardware:

Software

External cooperation (if any): Canadian Manufacturers' Association

Papers published (if any): CAN-MATE distributes a regular monthly bulletin called "Technology Source", which includes portions of the CAD/CAM Newsletter. CAN-MATE also includes the full CAD/CAM Newsletter, in its publicly accessable on-line data base.

Division: National Aeronautical Establishment (NAE)

Section: High Speed Aerodynamics Laboratory (HSAL)

Project title: Computer-aided Design and Manufacturing at HSAL

Project leader: Bill Brown **Phone no:** (613) 998-3455

Project description:

The HSAL uses CIM technology to manufacture aerospace models. In order to produce very accurate models, expertise has been developed in the following areas:

(1) Digitization of drawings for the development of a CAD/CAM database.
(2) Use of CAD/CAM software for design and manufacturing.
(3) Development of custom CAD/CAM software.
(4) Processing of N.C. code from a generic format to a machine specific format.
(5) Transfer of data to an N.C. manufacturing device (mill, lathe) through various mediums (papertape, direct link).

The present CIM environment in HSAL is being expanded to provide greater depth in design and manufacturing capabilities. The gradual transition to CAD as a main drafting tool is already underway. Further training of personnel, acquisition of more CAD/CAM access devices (workstations) and the implementation of a computer network scheme, devised to provide the NAE division-wide access to the HSAL CIM advantages, will complete the present plans for expansion. Future proposals include alternate manufacturing materials and tools.

Resources:

Persons: 4 designers, 1 shop foreman, 7 toolmakers, 2 technologists, 1 computer support person

Hardware: 1 Unigraphics D120 CE terminal, 1 Unigraphics D135 CE terminal, 1 Unigraphics D4111 terminal, 1 VAX 11/785 computer, 1 Mitutoyo co-ordinate measuring machine, 1 Deckel FP4 NC 3 axis milling machine, 1 Deckel FP42 NC 3 axis milling machine, 1 Maho MH 700C 3 axis milling machine, 1 Hardinge HXL NC lathe, 1 VDF DN570 NC lathe, 1 HP Draftmaster Plotter.

Software: ICAM TECHNOLOGIES CAM posting, Unigraphics CAD/CAM system, custom software, Smartworks PCB Design software (on IBM PC), Hiwire Schematic software (on IBM PC).

External cooperation (if any): The Division of Informatics supports the Unigraphics software on their VAX 11/780 computer. They provide a plotting service as well. A link has been established with Low Speed Aerodynamics Laboratory's Deckel FP4 NC milling machine.

Papers published (if any): Several unpublished papers are available from the HSAL in the form of lab memos.

Division: Institute for Marine Dynamics

Section: Research and Development Services

Project Title: Computer-Aided Design and Manufacturing at IMD

Project Leader: Tony C. Randell Phone: (709) 772-5012

Project Description:

In support of research activities at IMD the development of CAD/CAM tools for the design and manufacture of Ship's hulls and appendages has been the focus of ongoing activity. Software has been developed for defining ship's hull geometry and subsequent manufacture using a large custom built NC milling machine. A nev software package from BMT for ships lines fairing will be installed in the near future. This program, called BLINES, will be integrated into the existing system to help improve efficiency.

More recent work has been in the area of model propeller design and manufacture. Some initial programs have been developed for parametric definition of blade geometry as well as programs for milling the blades using a 5-axis NC milling machine. It is planned to develop a complete system for model propeller manufacture that may also involve producing patterns for casting of propeller blades with assistance from local industry.

Resources:

Persons: 1 RO, 1 CS, 1 TO

Hardvare: 1 VAX11/750, 2 Tektronix 4114 terminals, Calcomp 1073 plotter, 2 RT103 industrial controllers, Line' 5-axis NC Ship Model Milling Machine, Wahli W52 5-axis NC Milling Machine.

Software: (SMP programs,REVIEW,PROVE,RPROP,PROP_POST)These programs and others were developed in-house.

BLINES and BLUT programs from BMT (British Maritime Technology). (To be installed Spring 88)

Division: Mechanical Engineering

Section: Tribology and Mechanics Laboratory

Project title: Computer-Aided Design at Western Lab

Project leader: Tom Vanderhoek Phone no: 604-666-0790

Project description:

The Tribology Laboratory specializes in investigations of friction and wear characteristics of materials and components of mechanical systems involving sliding, rolling, and impact motion in scaled tests simulating end-use conditions.

The Mechanics Laboratory research is applied to the development of novel mechanical devices suitable for use in ecologically appropriate industrial practice.

The Design Manufacturing Group supports these activities using a Unigraphics II CAD system. The system includes 1 color workstation running off a DEC Microvax II. The software is an integrated system for design and drafting. Conceptual designs and detail drawings of laboratory test equipment are produced for manufacturing. Plotting is done by either electrostatic or pen plotter.

Resources:

Persons: 1

Hardware: Microvax II, Versatel 8222A, Hewlett-Packard 7580B

Software: Unigraphic II Design

External cooperation (if any): Nil

Papers published (if any): Nil

Division: Mechanical Engineering

Section: Manufacturing Technology Centre (MTC)

Project title: Computer Integrated Manufacturing (CIM)

Project leader: Dan Johnston Phone no:993-6627

Project description:

The MTC is involved in the application of computers to design and manufacture of mechanical components. This work can be separated into two areas: productive use of the CAD/CAM system for design, and development work. This sheet describes the development work, see the project "MTC Design Office" for information on the first project mentioned.

MTC's development efforts in CIM have been focused on the manufacture of prototypes and small batches of sculptured surface objects. This has lead to development work in four areas: tool path generation, adaptive cell control, manufacturing shop productivity, and sculptured surface inspection.

In cell control, a cell has been developed to manufacture prototype parts unattended, in small batches. Efforts are continuing to raise the sophisticated capabilities of the cell, and transfer some of the in-house technology to industry.

Tool path generation is a major part of the prototype manufacture effort. Since the installation of the CAD/CAM system in 1983, continuing efforts have been devoted to enhance the productivity and capabilities of the CAM functions. The group is currently considering developing an NC program editor with special features to speed the development, proving, and correcting of sculptured surface toolpaths.

A project has been started to automate the main shop, including providing low cost program communication between the computing network and CNC machine tools.

In inspection, a system has been developed which integrates the CAD/CAM database with the output of a coordinate measuring machine (CMM). This allows the measurement of sculptured surfaces for quality assurance and feedback to the manufacturing cell. Work is currently underway on a package to inspect turbine blade sections.

Resources:

Persons: three PY's plus support staff

Hardware: Wahli-51 machining center, Asea IRB-60 robot, VAX-based computer network and cluster

Software: Unigraphics CAD/CAM system, ICAM postprocessor, Fortran, 'C' compilers, application software (as described above)

External Cooperation: Department of National Defense, Pratt & Whitney

(Papers listed on next page)

Papers:

Johnston D.F.; Small Batch Manufacturing Using a Prototype Automated Cell, Proceedings of the Second Annual International Conference on Computer-Aided Production Engineering, Scotland, April 13-15 1987.

Orban P.; Talking to Machine Tools: DNC Coupler Design, Proceedings of the Eigth Symposium on Engineering Aplications of Mechanics, Department of Mechanical Engineering - University of Sherbrooke, Sherbrooke 1986.

Orban P., The G., Van den Berg G.; A Robot Based CMM - Feasibility Study, To be published in Proceedings of Manufacturing Automation Programming Languages Conference, June 22-24, 1988 Winnipeg Canada.

Van den Berg B.; Closed Loop Inspecton of Sculptured Surfaces in a Computer Integrated Manufacturing Environment, Automated Inspection and Production Control, Proceedings of the 8th International Conference, IFS (Publications) Ltd, Bedford UK.

Van den Berg B.; Post Processing in a DNC Environment, Proceedings of the Eigth Symposium on Engineering Aplications of Mechanics, Department of Mechanical Engineering - University of Sherbrooke, Sherbrooke 1986.

Van den Berg B.; Automated Part Set-up for NC machining of Sculptured Surfaces, To be published in Proceedings of Nineth Engineering Applications of Mechanics

DIVISION: Industrial Materials Research Institute

SECTION: Systems and Instrumentation

PROJECT TITLE: Computer Integrated Material Processing (CIMP)

PROJECT LEADER: Georges SALLOUM **PHONE:** (514) 641-2280

PROJECT DESCRIPTION:

Modelling and simulation of materials behaviour under processing and service conditions. Present activities cover moulding, casting and forming processes. Development of computer-integrated software for the design and manufacturing of products and tools specific to these processes:

- Injection moulding of plastics, rubbers and composites.
- Injection moulding of ceramic and metal powders.
- Die casting of metal alloys.
- Injection and extrusion blow moulding of plastics.
- Forging and rolling of metals.

RESOURCES:

PERSONS: 18

HARDWARE: DEC VAX 11/785 under VMS, Applicon workstations.

PROCESSING EQUIPMENT: Extruders: 1" & 2" pipes, profile, sheet, and blown film. Injection molding machine: 4 oz., 70 tons, ASTM mould and others. Compression moulding machine: 100 tons. Blow molding machine Bottles.

SOFTWARE: Applicon's Bravo software, special application softwares (ANSYS, POLYFLOW, FATIGUE, SOLID MODELLING).

EXTERNAL COOPERATION: Institut fur Kunststoffverarbeitung, Aachen, FRG.
Battelle Columbus Laboratories, Columbus, Ohio, USA.
McGill University, Montréal.
Polymers Processing Institute, Hoboken, NJ, USA.
Université Catholique de Louvain, Laneuve, Belgique.
Center for Composite Materials, University of Delaware, USA.
Ecole Polytechnique, Montréal.
Université de Sherbrooke, Sherbrooke.

INDUSTRIAL PARTNERS: I.P.L., I.T.L., CANALLOY, BNR, FISHER CAST, NORANDA, UNICAN, LYSTER, Eastern Die Casting, GOODYEAR Canada, Dupont Canada, ICAM Technologies.

RECENT PUBLICATIONS:

Rata G.L., Salloum G., "Computer Integrated Material Processing (CIMP) - A Generic Application of CAD/CAM Technology", Engineering Materials Design, June 1987.

IMRI'S R&D CAPABILITIES IN COMPUTER INTEGRATED MATERIALS PROCESSING

1. MATERIAL DATABASES

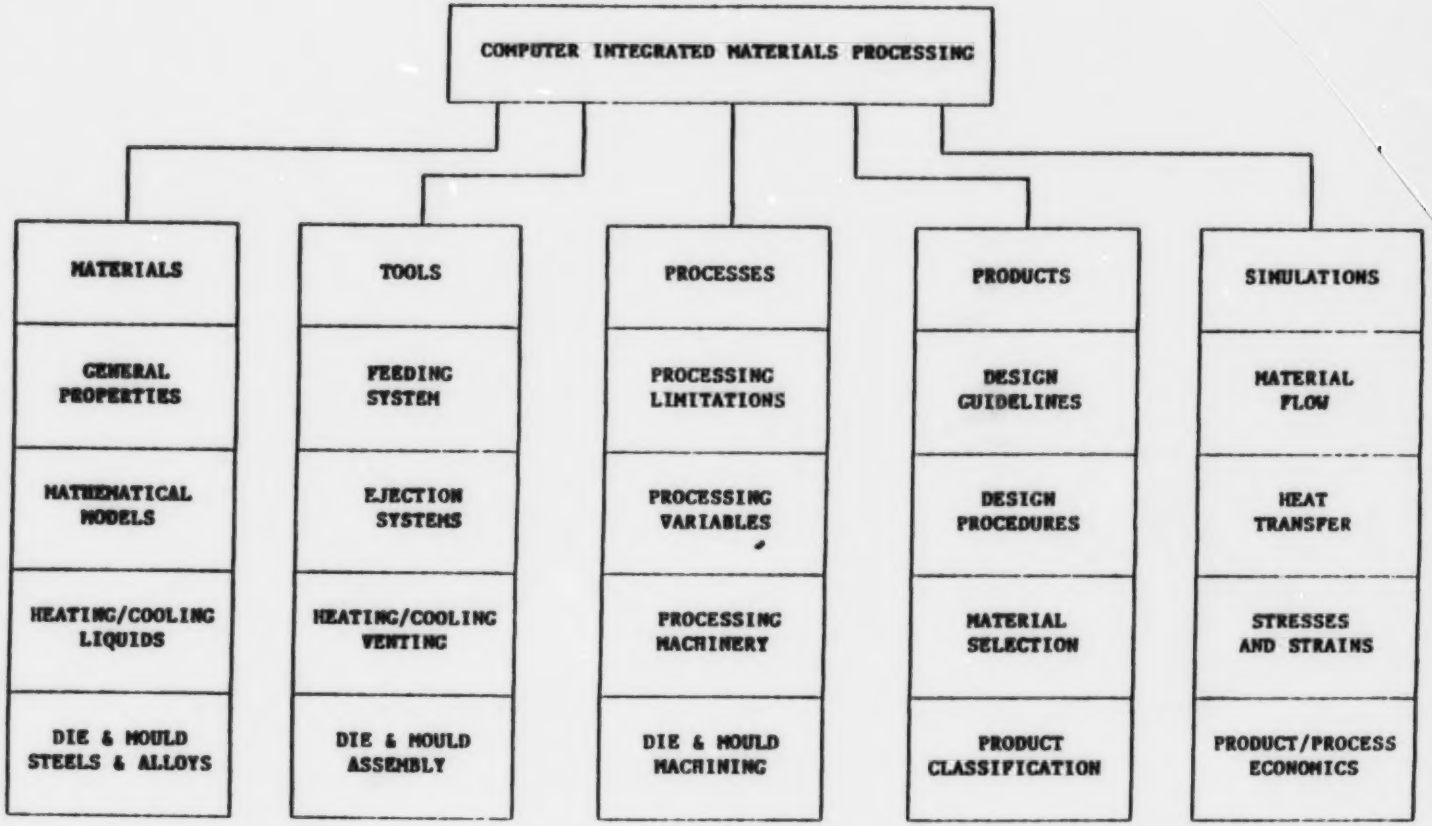
- Modelling of material properties in solid and liquid phases (mechanical, thermal, rheological, etc.)
- Modelling of process and service dependent material properties and processing conditions
- Computer assisted material selection, comparison and evaluation of polymers, composites, nonferrous alloys and tool steels

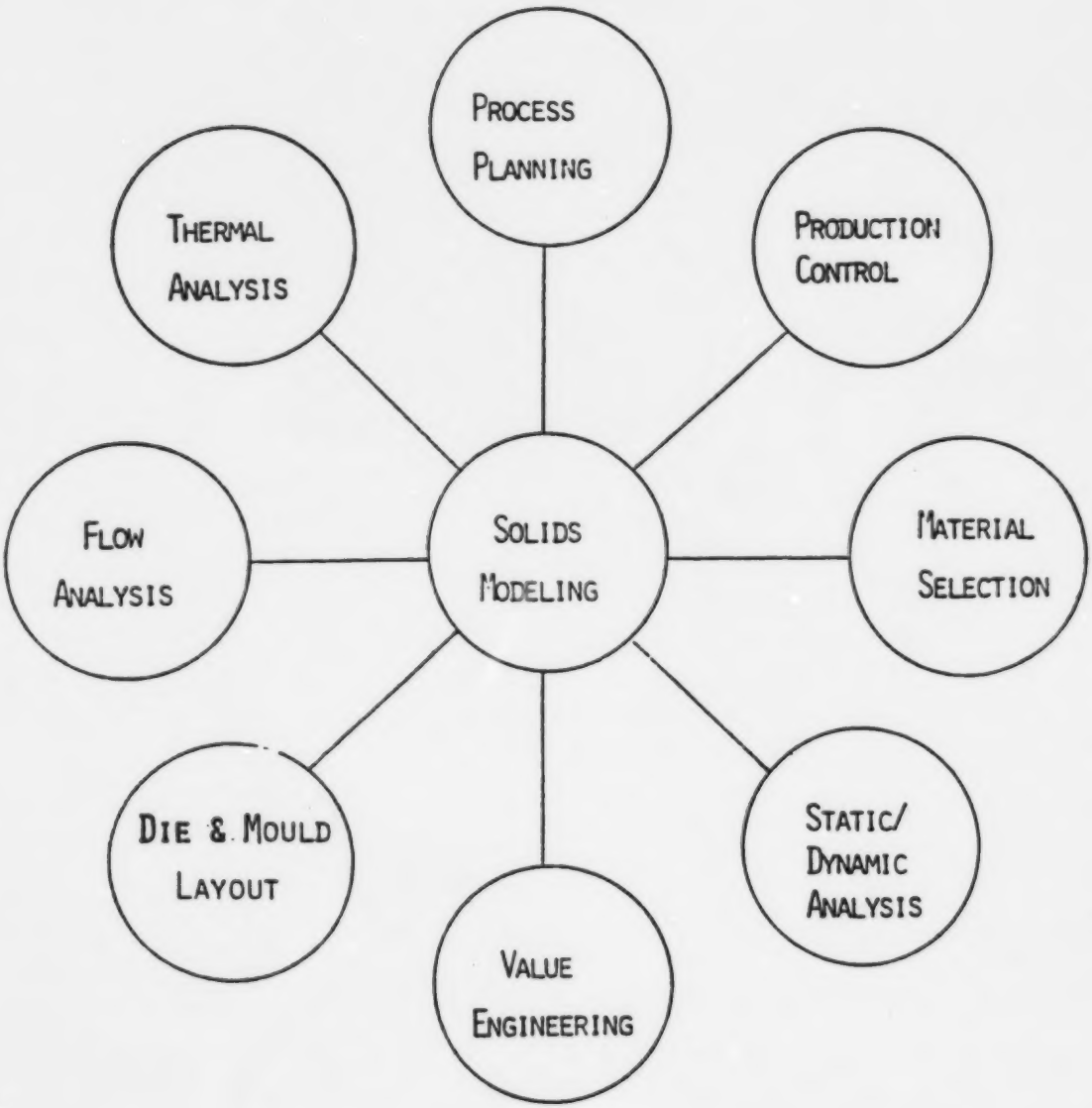
2. PRODUCT DEFINITION AND OPTIMIZATION

- Interactive design tools (surface and solid modelling)
- Finite element modelling and analysis based on predictive design methodology (static, dynamic, creep, fatigue, thermal, isotropic, anisotropic, elastic and plastic behaviour)
- Design optimization by processing and service requirements

3. PROCESS SIMULATION AND TOOLING

- Material flow, cooling and shrinkage simulation for designing dies and moulds
- Optimization of processing conditions for moulding, casting and solid forming operations
- Design-manufacturing CNC interfaces for maximizing production and control.


COMPUTER INTEGRATED MATERIALS PROCESSING
MATERIALS
GENERAL PROPERTIES
MATHEMATICAL MODELS
HEATING/COOLING LIQUIDS
DIE & MOULD STEELS & ALLOYS
TOOLS
FEEDING SYSTEM
EJECTION SYSTEMS
HEATING/COOLING VENTING
DIE & MOULD ASSEMBLY
PROCESSES
PROCESSING LIMITATIONS
PROCESSING VARIABLES
PROCESSING MACHINERY
DIE & MOULD MACHINING
PRODUCTS
DESIGN GUIDELINES
DESIGN PROCEDURES
MATERIAL SELECTION
PRODUCT CLASSIFICATION
SIMULATIONS
MATERIAL FLOW
HEAT TRANSFER
STRESSES AND STRAINS
PRODUCT/PROCESS ECONOMICS



COMPUTER INTEGRATED PRODUCT DEVELOPMENT

Division: Electrical Engineering

Section: Robotics & Automation, Laboratory for Intelligent Systems

Project title: Design of 3-D NC CAD Database For a PC

Project leader: Jeff Allston **Phone no:** 204/983-2617

Project description:

The development of a CAD database specifically for numerically controlled machines was undertaken in conjunction with ICAM Technologies. This project is the nucleus of a much larger project called I3D being developed by ICAM. The I3D project is intended to group a number of ICAM's CAD and CAM developments together to arrive at an integrated solution to a number of manufacturing problems. At the centre of the I3D project is the 3-dimensional relational database used to collate all necessary data from the ICAM product developments.

Resources:

Persons: 1

Hardware: VAX 8530, IBM PC

Software: C Compiler on both computers

External cooperation (if any): ICAM Corporation

Papers published (if any): None

Division: Electrical Engineering

Section: Robotics & Automation, Laboratory for Intelligent Systems

Project title: Development of Industrial Automated Guided Vehicle (AGV) System

Project leader: P. Orban **Phone no:** 204/983-3478

Project description:

Industry is increasingly using AGV systems for their material handling needs. To meet this need, AGV companies are continually improving their AGVs to remain competitive and offer industry the most flexible, efficient, and safe material handling solution. With the participation of FMC of Canada LTD, the project is looking at ways to improve the performance and services provided by AGV systems.

Areas of improvement being considered are system controller design, increased local "intelligence" of vehicle with powerful on-board computers and sensors, and improved communication and guidance system for the vehicle. In addition, AGV systems are often viewed as an engineered system and not an off-the-shelf item, thus there is room for improved AGV system design methodology to reduce engineering costs.

Resources:

Persons: 3

Hardware: MicroVAX II

Software: C, Lisp, ADA

External cooperation (if any): FMC of Canada LTD.

Papers published (if any):

Division: Electrical Engineering

Section: Robotics & Automation, Laboratory for Intelligent Systems

Project title: Expert Off-line Programming System for Robotic Painting

Project leader: P. Orban **Phone no:** 204/983-3478

Project description:

Vadeko International Inc. and the Robotics & Automation Section is working jointly on a project to automate the programming of robotic painting. The project sets up the framework for a computer aided robotic painting cell programming system.

The programming system is conceived as a collection of modules that share a central database. Some of the modules will be at least partially commercially available while others require considerable research and development.

In the first phase, the project will focus on two key modules, the Trajectory Planner and the Paint Deposition Simulator. The integration of these two modules into an existing CAD/robot simulator package will be addressed as well.

Resources:

Persons: 6

Hardware: MicroVAX II GPX Workstation, Evans & Sutherland graphics workstation

Software: UNIGRAPHICS II, McDonnell Douglas
PLACE/COMMAND/BUILD/ADJUST, C, FORTRAN compilers

External cooperation (if any): Vadeko International Inc.

Papers published (if any):

Division: Electrical Engineering/Mechanical Engineering

Section: Industrial Liaison Office, DEE/Systems Laboratory, DME

Project Title: Industrial Automation Glossary

Project Leader: J. Scrimgour/J. Buckley Phone no: 993-9000
993-9458

Project description:

As a contribution to the establishment of international standards in industrial automation by the International Standards Organization (ISO), the development of a glossary of terms in industrial automation is in progress. Appropriate material is being assembled for input using optical character recognition (OCR) techniques into a relational data base on a personal computer in conjunction with the Division of Mechanical Engineering.

Specifically this is an undertaking of ISO/TC184/SC5/WG3. Using source material both internal to ISO and from external sources, with copyright release where required, a moderately extensive data base of industrial automation terms & definitions has been assembled. The initial print out for English language terms is a 1400 page report of approximately 7000 entries. Print out of a second draft report listing terms and definitions in the French language is in progress.

The working group for the project currently consists of a small number of volunteers from several countries, and has been adequate for the task to date. Additional volunteer members are now needed to undertake the more extensive task of editing, consolidating & translation. It should be noted that in addition to developing this specific glossary, a database & software system, with OCR input capabilities, has been created which could be useful for other projects.

Resources:

Persons: 2

Hardware: IBM PC

Software: ZIM relational database plus custom software for handling OCR input files & report generation.

External cooperation (if any): International Standards Organization (ISO)

Papers published (if any): ISO/TC184/SC5/WG3
Industrial Automation Glossary
Initial draft working paper, March 1988.

MANUFACTURING SUPPORT SYSTEMS.

Udo Graefe, Systems Laboratory, DME.

PROGRAM OBJECTIVE:

To promote, assist and perform research for the creation of new knowledge or the application and refinement of existing knowledge in support of manufacturing activities.

The program team fulfills this objective through the use of tools such as mathematical modeling and analysis, operations research, artificial intelligence and systems design and development.

RECENT AND CURRENT ACTIVITIES:

1. Production Planning, Scheduling and Simulation for Manufacturing Plants. Collaboration with ICAM Technologies. Pointe Claire, Quebec.

2. Constraint Based Scheduling.
   - Aging furnace scheduling. ALCAN.
   - Scheduling of felt making operations. Huyck Canada.
   - Scheduling of rolling mills. Collaboration with CIIT & Manitoba Rolling Mills, Selkirk, Manitoba.
   - Capacity planning in garment industry. Collaboration with CIIT & Nygård, Winnipeg, Manitoba.

3. Manufacturing Shop Controller. Collaboration with:
   - Allen-Bradley Canada, Cambridge, Ontario.
   - Westhead Associates, Rexdale, Ontario.

4. International Standards Organization Activities. (ISO).
   - ISO TC184. Industrial Automation Systems.
   - ISO TC184 SC5. Systems Integration and Communication.
   - ISO TC184 SC5 WG1. Reference models for discrete parts manufacture.
   - ISO TC184 SC5 WG3. Glossary of terms for industrial automation.

5. NRC Industry Development Office. (IDO).
   - Aspects of CIM in shoe manufacturing. BATA-CIMTECH.
   - Modeling of, and decision making in mini steel plants. Northern Dynamics.

FUTURE ACTIVITIES:

1. Simulated Manufacturing Research Facility. (SMRF).

2. Application of Artificial Intelligence to Manufacturing.

Division: Electrical Engineering

Section : Photonics and Sensors

Project title: Photonics applied to sensors

Project leader: J. Domey **Phone no:** 613-993-2557

Project description:

The objective of the Photonics and Sensors Section is to develop new sensors and sensor systems for autonomous systems, combining optical, electronic and computer techniques. There are presently two related activities: 1) tridimensional vision and 2) development of optical components and techniques for high speed sensing and signal processing.

The research on 3-D vision involves the development of new optical techniques for accurate and fast acquisition of 3-D data from a scene and the processing of this data for object recognition and CAD/CAM application.

The research on optical components and techniques involves investigation of nonlinear and integrated optic techniques to realize new sensors and high speed signal processing elements and systems. To support these activities the Section has the following computing facilities: a Microvax GPX workstation clustered with the VAX 11/750 with a CSPI Minimap array processor and a Trapix image processor.

Resources:

Persons: 15

Hardware: Microvax GPX, VAX 11/750 under VMS, CSPI Minimap array processor

Software:

External cooperation:

Hymarc Eng.	Interface between the 3D Vision Sensor and CAD/CAM Systems using IGES III protocol

January 1988

Division: Division of Electrical Engineering

Section: Computing Technology, Laboratory for Intelligent Systems

Project Title: Sensor-based Robotics

Project Leader: N. Burtnyk **Phone No:** 993-0261

Project Description:

The long range goal of this project is to develop a sensor based robot system which is capable of performing complex assembly tasks in an uncertain and changing environment. As a computer based technology, this is essentially a problem in sensor based control of a complex realtime system, and our emphasis in this project is on how to express this control in terms of viable computing systems. No direct effort is being applied to advancing or enhancing the robot mechanism itself. Instead, focus is on enhancing the capability of industrial robots through the addition of sensory function and intelligent control. The technology to deliver this enhanced capability represents an important potential market for Canadian industry in the form of value added components to existing commercial products. The makeup of these activities is strongly influenced by the existence within the laboratory of two strong companion projects in Harmony development and 3D sensor technolgy. Work in this project covers the areas of intelligent control, robot vision and autonomous task planning. The Harmony realtime operating system is being used to implement a versatile robot control structure that readily accommodates integration of sensory functions within a complex system control environment. This will provide the basis for future experimentation in coordinated multiple arms working on a common task with sensing feedback from multiple sources. A wrist mounted laser scanner, based on the 3D sensor technology from the Photonics and Sensors Section, has been developed for robot vision. It has been used initially to support experimentation in part acquisition and tracking. At present, its application to problems in recognition in the space station environment is being investigated. Further development to enhance the capability of the wrist camera is continuing in collaboration with McGill Robotics Laboratory. For a robot to perform tasks in a variable environment, it must be able to reason about space as well as formulate and execute plans autonomously. Knowledge based techniques and artificial intelligence are being used to develop methods for path planning with collision avoidance and for robot task level programming and task planning.

Resources:

Persons - 9
Hardware - 3 PUMA robots, 3 VME/68020 Harmony machines, 2 LISP machines, VAX/780, network of Macintosh workstations, variety of sensor components
Software - ART, RCCL, Harmony RTOS

External Cooperation:

Collaboration with external partners to exploit this technology includes the following:

- Harmony robot controller - P-CAN, Vadeko
- Wrist mounted scanner - Servo Robot
- Range vision in space - SPAR
- Enhanced profile scanner - McGill
- Tactile sensor development - CPSC
- Harmony/RCCL controller - McGill, RSI

Papers Published:

1. Roth, G. and O'Hara, D. "A holdsite method for parts acquisition using a laser rangefinder mounted on a robot wrist", 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, 30 March - 3 April 1987. NRC #27171.

2. Rioux, M., Bechthold, G., Duggan, M., Taylor, D. "Design of a large depth of view 3-D camera for robot vision". Published in Optical Engineering Journal 26(12), December 1987. pp. 1245-1250.

3. O'Hara, D.H. "Prismatic shaped block insertion: an application of a multiprocessor robot controller using Harmony". NRC/ERB-1006.

4. O'Hara, D.H., Elgazzar, S.E. and The, G. "Alter-Harmony: Control of a PUMA robot from the Chorus multiprocessor". NRC/ERB-1002.

5. Archibald, C. "Automated Vision: Fundamentals and general overview". Proceedings of the 2nd National Symposium on Computer Image Processing, Chisholm Institute of Technology, Caulfield, Victoria, Australia. July 14-15, 1987. pp. B1-B1.4.

6. Archibald, C. "Case studies in machine vision: companies and applications". Proceedings of 2nd National Symposium on Computer Image Processing, Chisholm Institute of Technology, Caulfield, Victoria, Australia. July 14-15, 1987. pp. B6.2-B6.5.

7. Archibald, C. "Trends in automated vision". Proceedings of the 2nd National Symposium on Computer Image Processing, Chisholm Institute of Technology, Caulfield, Victoria, Australia. July 14-15, 1987. pp. C1-C1.6.

8. Domey, J., and Burtnyk, N. "3D vision for robotics and automation". Proceedings of the Canadian Engineering Centennial Convention, Montréal, P.Q., May 18-21, 1987. pp. NRC 27959.

9. Gentleman, W.M., MacKay, S.A., Wein, M., Stewart,D.A., Parr, R.K. and Green, D. "Harmony, an operating system for embedded industrial multiprocessor applications", Proc. Compint '87, Montréal, P.Q., November 10-12, 1987. pp. 249-252.

10. O'Hara, D. "Multiprocessor robot control for assembly: A demonstration with tactile feedback for prismatic shaped block insertion", 7th International Conference on Robot Vision and Sensory Controls, Zurich, Switzerland, February 2-4, 1988.

Division: Informatics

Branch: Computing Services

Service: Unigraphics CAD/CAM Service

System Manager: John Seddon Phone no: 613-993-0240

Service Description:

The Computing Services Branch offers computing services to all divisions of NRC on a cost-recovery basis. CAD/CAM services are based on the Unigraphics and ICAM software, running on a VAX 11/780 which was relocated from DME in 1986. Workstations located in the research divisions are connected to the 780 via Bell lines and a Gandalf PACX. Unigraphics users send designs via Decnet to plotting facilities on a VM system. Computing Services contracts hardware and software maintenance for all components except the workstations.

Unigraphics licencing has been extended to allow Unigraphics to be run on several MicroVAX acquired by the research divisions. A large portion of the Unigraphics workload is expected to migrate off the 780 during FY88. MicroVAX at user sites have access via Decnet to plotting facilities on VM.

Resources:

Persons: 1 PY

Hardware: VAX 11/780, 24MB memory, 800MB disk, 1600/6250 bpi tape

Software: VMS, Decnet, Unigraphics, ICAM, Fortran, C

External cooperation (if any): NA

Papers published (if any): NA

Division: National Aeronautical Establishment

Section: High Speed Aerodynamics Laboratory (HSAL)

Project title: Wind Tunnel Model Design and Manufacture

Project leader: Denis Brown **Phone no:** (613) 998-3309

Project description:

The High Speed Aerodynamics Laboratory is engaged in the design and manufacture of accurately scaled aircraft models for aerodynamic investigations in the 5ft X 5ft blowdown wind tunnel.

The high degree of precision required in the finished product requires the application of C.I.M. technology and the high dynamic pressure test environment demands the use of high strength steels in some highly stressed areas of a model.

The requirements are being met through the expanding use of a CAD-CAM system and the application of a modern 3-coordinate measuring machine and a number of programmable machine tools.

A procedure to machine components of a model currently in manufacture has invoked the following steps:

(1) Use of a co-ordinate measuring machine to produce accurate co-ordinates of model from cross sections.
(2) Data smoothing and spline fitting.
(3) Production of a CAD model utilising sculptured surfaces that were developed from splines.
(4) Contouring of CAD model using integral CAM software and processing of numerical instructions to a specific machine tool controller format (NC data produced).
(5) Transfer of NC data between computing devices and specific machine tool through a direct computer link.
(6) Machining.

Resources:

Persons: 1 aerodynamicist, 1 mathematician, 3 designers, 1 shop foreman, 7 toolmakers

Hardware: 1 Unigraphics D-120CE design station, 1 Unigraphics D135CE terminal, 1 Unigraphics D4111 terminal, 1 VAX 11/785 computer, 1 Maho MH-700C milling M/C, 1 Deckel FP42NC milling M/C, 1 Deckel FP4NC milling M/C, 1 Hardinge HXL lathe, 1 VDF-Boehringer DN570 lathe, 1 Mitutoyo B241 co-ordinate measuring M/C

Software: Unigraphics CAD/CAM, ICAM TECHNOLOGIES CAM posting and custom software by HSAL.

External cooperation (if any): A Deckel FP4NC milling machine installed in the Low Speed Aerodynamics Laboratory (LSAL) has been linked to the HSAL computer to provide further machining capacity. This is a mutually beneficial arrangement which expedites manufacture of the current model and provides the staff of the LSAL with direct CAM experience.

Papers published (if any): Some unpublished papers are available on request to HSAL.

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